SURVEY OF OKLAHOMA SECONDARY SCIENCE TEACHERS AND THEIR FACTUAL KNOWLEDGE OF SCIENTIFIC PRINCIPLES CONTAINED IN EIGHT ISIS MINICOURSES

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ISIS MINICOURSES

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CHAPTER I

THE NATURE OF THE PROBLEM

Introduction

Teachers and science educators have expressed concern about the content of the secondary science curriculum. These curricula tend to emphasize theory rather than providing experiences which relate to the interaction of science, technology, and the society (24). Programs that have employed the development of abstract concepts have proven difficult and unattractive for many students, and their relevance has become increasingly difficult to defend (21). This is especially true at a time when the public is questioning the impact science and technology is having on the society. Many science teachers have felt constrained by the inflexibility of programs that are bound in year-long sequences (24). As a result, efforts are being made to develop alternative curricula that are more flexible and multidisciplinary (25).

There is evidence that students share teachers' and educators' concern about science courses. The introduction of the new curricula during the past fifteen years has not increased student enrollments in science, particularly the physical sciences (11, 40).

Finally, schools have been under increasing pressure from communities to justify their expenditure in terms of demonstrable outcomes in student learning. Science education has not escaped this call for accountability. It has prompted some teachers to rethink the science offered in their school and, in some instances, restructure their program around highly specific and measurable objectives.

It was concerns such as these that led the National Science Foundation to sponsor a meeting of science teachers and scientists at Callaway Gardens, Georgia, in October, 1971. The conference delegates discussed the content and implied teaching strategies of the current curriculum programs with respect to the needs of today's schools. They concluded that the progress of the past fifteen years has prepared the way to take a new step and that a new step is indeed needed. They recommended the development of an alternative curriculum that focuses upon one that provides a balance between theoretical and applied science, that places considerable emphasis upon social implications and that emphasizes measurable objectives without losing sight of the affective dimensions of learning (24).

Following the Callaway Gardens Conference, a proposal was made to the National Science Foundation to support an effort to implement the conference recommendations. The proposed project, which has since been titled the "Individualized Science Instructional System Project," was funded in late 1972 (25).

The ISIS project is indeed an ambitious effort. The plans call for several hundred teachers, administrators, scientists and educationists to develop cooperatively 80 instructional modules and an associated instructional management scheme that will provide proven and practical ways for teachers to use these materials most effectively.

Definition of Terms

1. Individualized Science Instructional System (ISIS): This is a

multi-disciplinary approach to the study of secondary science. The entire program, when completed, will consist of 80 minicourses and a classroom management scheme. At the time of this study only ten minicourses had been produced and were in the pilot phase of the program. Eight of these ten minicourses were used in this study.

2. Minicourse: Each minicourse is a complete learning packet for the student. The eight minicourses used were:
   a. "Things That Last": This minicourse basically involves principles governing the manufacture of substances which must endure various environmental conditions.
   b. "The Computer Age": This minicourse studies principles of computer programming and operation.
   c. "Buying and Selling": The principles of product development, promotion, and marketing are presented in this minicourse.
   d. "Packaging Passengers": Principles of automobile safety are presented in this minicourse.
   e. "Heart Attack": This minicourse contains information on the human circulatory system.
   f. "Getting Enough Oxygen": The respiratory system and cellular respiration are covered in this minicourse.
   g. "The Generation Link": Principles of genetics are presented in this minicourse.
   h. "Gut Reactions": This minicourse studies the digestive processes in man.
3. Scientific Facts: This term refers to basic factual knowledge

of scientific information contained in the various minicourses.

Need for the Study

Several authorities over the past years have indicated that many of the curricular programs in the sciences have failed because of inadequate teacher preparation (29, 40). It is imperative that those involved in teacher education and science program development know what content background is needed by teachers in order to effectively implement the ISIS Program. It is hoped that this study will indicate in which areas Oklahoma secondary science teachers have strengths and weaknesses with the scientific principles contained in the eight ISIS minicourses investigated in this paper.

Purpose

The purpose of this study was to determine Oklahoma secondary science teachers' factual knowledge of scientific principles contained in eight ISIS minicourses. The compiled data will be used to develop preservice and inservice programs dealing specifically with the teaching and implementation of ISIS.

Major Research Questions

The major research questions proposed for investigation were as follows:

A. What factual knowledge do Oklahoma secondary science teachers possess of the scientific principles basic to the eight ISIS minicourses discussed below:

   1. "Things That Last"

2. "The Computer Age"

3. "Buying and Selling"

4. "Packaging Passengers"

5. "Heart Attack"

6. "Getting Enough Oxygen"

7. "The Generation Link"

8. "Gut Reactions"

Supplemental Questions

In addition to the above research question, the following supplemental questions were investigated:

A. Which teacher scored higher?

   1. Those with BS degree

   2. Those with MS degree

B. Is there a significant relationship between the type of degree held and performance on diagnostic instrument?

C. Which teachers scored higher?

   1. Those with an undergraduate major in physical sciences

   2. Those with an undergraduate major in the life sciences

D. Is there a significant relationship between an undergraduate major in the life sciences and the physical sciences and performance on diagnostic instrument?

E. What are the educational and demographic data of teachers who were studied?

   1. Number of years of teaching experience

   2. Number of years of teaching experience in present school

   3. Major in college

4. Number of hours of college credit in the sciences (life and physical)
5. Highest degree held
6. Number of years that have elapsed since attending a college level class as a student
7. Age
8. Population of the city in which respondent teaches
9. Size of school in which respondent teaches
10. Number of science teachers in the particular school in which respondent teaches
11. Membership in Oklahoma Science Teachers Association
12. Membership in other organizations

Major Assumptions

For the purpose of this study the following assumptions were posited:

A. The diagnostic instrument used in this study was a valid instrument for determining the factual knowledge of a sample of Oklahoma secondary science teachers concerning the scientific principles contained in the eight ISIS minicourses investigated.

B. Those teachers responding were representative of the secondary science teachers of Oklahoma.

C. Those teachers responding were competent in their field of teaching.

Limitations of the Study

This study was intended to be an initial thrust into a previously unexplored area, consequently, results should be considered tentative, providing base data for more elaborate research. Generalizations drawn from the findings should be limited to the responding teachers of Oklahoma.

CHAPTER II

REVIEW OF SELECTED LITERATURE

Introduction

Gardner (11) indicated that anyone in teacher education who is not concerned with the present status of science education and not seeking new solutions is too isolated from reality. It is the belief of this writer that teacher preparation colleges, or divisions of larger universities concerned with teacher preparation, must always be atuned to the needs of society, and as a consequence, be prepared to educate and reeducate science educators accordingly. Careful attention needs to be paid to content and methods, both for preservice and inservice teacher education.

This review is divided into four segments: (1) Preservice Education, (2) Inservice Education, (3) Rationale for Science Concepts, and (4) Contemporary Thought As Applied to the Individualized Science Instructional System Program.

Preservice Education

Liberal Education

All teachers should be liberally educated people (41, 15). Through an education that generally informs students of world problems, future teachers will be best prepared to meet the challenges and problems of teaching. Education in science is an essential part of liberal education and the guideline descriptions of the kinds of experiences that the teacher education institution should provide for the preparation of secondary science teachers are believed to be essential to liberal education. It is essential for the liberal and professional education of the secondary science teacher to study the philosophy of science, to have multidisciplinary experiences that will strengthen his understanding of the issues related to science, technology, and society; to be competent in oral and written communication; and to develop the idea of commitment to a lifetime of learning.

It is expected, and indeed it is essential that every teacher education institution provide a broad education for secondary science teachers. Certainly no state department of education will certify any teacher without that teacher having been exposed to a liberal education.

Many of the objectives of science teaching are shared by all science instruction at all grade levels and in all the various science subjects (15, 16, 17). Among these objectives are: (1) as high a level as possible of scientific literacy necessary for intelligent citizens of today; (2) development of a concept of science as an accumulated body of knowledge and of a concept of scientific methods of inquiry; (3) development of modes of thought that encourage critical thinking and problem-solving ability; (4) understanding the basic concept of interrelatedness of the various science disciplines with other disciplines; (5) understanding the broad concepts and principles of scientific knowledge; and (6) a penetrating understanding of the relationships of current science and societal problems (15).

Science courses, taught with these objectives in mind, are not only essential for the preparation of well-qualified science teachers, but are also appropriate for inclusion in the program of general education (15).

Common Guidelines

It is not necessary that all institutions adopt a uniform pattern of organization of providing the subject-matter preparation for the science teacher. Some institutions with a divisional organization may offer a curriculum for the preparation of science teachers through a single division. Others, with a departmental pattern of organization, may offer individual teaching majors through separate science departments, such as physics, chemistry, and biology. Whatever the type of organization, the subject matter portion of the teacher's preparation should constitute a pattern carefully planned in accordance with common guidelines (16).

The most comprehensive set of guidelines available in the literature appears to be those adopted by the National Association of State Directors of Teacher Education and Certification and the American Association for the Advancement of Science with the support of the Carnegie Corporation of New York. The Guidelines, to be discussed later, are in agreement with those set forth by the National Council for Accreditation of Teacher Education, which include the following:

1. All teacher education programs should provide enough general education such that all teachers will be broadly educated and cultured persons.
2. All teacher education programs should provide adequate in depth study of chosen field such that teachers become

specialists in that field.

3. All teacher education programs should provide information and practice which will lead teachers to competency in chosen field.

An Overview of "Guidelines and Standards for the Education of Secondary School Teachers of Science and Mathematics" (15)

Guideline one proposes that teacher education programs should encourage personal growth in human qualities that will aid the learning process in students (15).

One of the greatest needs of a student is a sustained relationship with a major professor. This relationship will develop confidence, a spirit of belonging, and will show the preservice educator the need to develop this kind of relationship with students.

The preservice teachers need to be exposed to various conditions surrounding teaching situations. Simulation games, which place student in another role, will help him deal effectively with the many problems which may arise.

Role-playing situations are often effective in helping preservice teachers develop the quality of sensitivity to students' needs. Teachers who cannot "get involved" with the student are often ineffective in the overall development of their students.

Guideline two suggests that teacher education programs should provide opportunity for students to relate science, technology, and society to one another in multidisciplinary approaches (15).

Science, as a body of knowledge, influences all members of our society. Science has caused, and will continue to cause, society to change her moral, theological, and legislated laws.

One of the major responsibilities of teaching science should be to help young people understand these fast changes and help them to adjust to those changes. Thus the teacher of science needs to be able to relate science and technology to societal changes.

There is some feeling that, in order to relate science and technology to societal change, the preservice educator have a broad education in the sciences, rather than a specialty. Teacher education institutions should provide a broad group of scientific experiences for their students.

It may well be that the science teacher may come to serve in the role of mediator between science and technology and society. To fill this role, one must of necessity be a generalist and be able to convey his message in an intelligible manner.

Guideline three suggests that teacher education programs should provide an opportunity for the prospective teacher to study the history and philosophy of science (15).

Many times the teacher is asked to express his philosophy as to the role of science in society. In order to do this in an effective manner, he must be acquainted with the philosophy of science.

An understanding of the philosophy of science also aids the science educator to better relate science to himself, and himself to society.

Guideline four proposes that teacher education programs should provide breadth in several fields of science while providing depth in chosen teaching field (15).

Teacher education programs must be responsive to the changing times. Curricula are changing and the teacher's role is also changing. The curricular changes of the 1960's introduced inquiry learning to secondary students of science. However, teachers maintained the status quo in terms of preparation. "There is currently beginning a movement to fuse the disciplines by emphasizing the common principles, concepts and processes and by teaching science in interdisciplinary or multi-disciplinary contexts that are problem oriented" (15). If this fusion is to take place, the teacher will have to be broadly educated in the sciences. He can no longer be content with a "specialty only."

Guideline five suggests that prospective teachers should be equipped with minimal mathematical competencies (15).

One of the most neglected areas of science teacher preparation is that relating to mathematics for science teachers, especially those teaching the life sciences. Some institutions have begun to offer mathematics specifically needed by the various science specialties. This is a large step forward because mathematics is basic to the understanding of many scientific principles.

It will be helpful for the science teacher to have some familiarity with the nature and method of modern school mathematics so that he can communicate easily with mathematics teachers in correlating science and mathematics programs and so that he may be more helpful to his students who may not be accustomed to viewing mathematics as a functional tool.

Guideline six suggests that teacher education programs should provide opportunity to search out new facts, and then present them in written or oral form (15).

Being able to read new material and translate that material to special needs is basic to any academic area. But it is especially important in science because of the interaction of society and technology. Teacher educators should provide the student, possibly through seminar activities, with opportunities to explore and communicate to others new findings in science.

Oral communication of new ideas should be emphasized in teacher education. The teacher uses primarily oral communication when teaching classes. For this reason, ample opportunity for oral expression should be included in any teacher preparation program. These experiences may include "oral reports," preservice experience during each year of teacher preparation, and presentation of learning modules in a variety of courses during undergraduate preparation.

Guideline seven suggests that teacher education programs should provide ample opportunity for the prospective teacher to "learn" about learning conditions (15).

The most important thing for a teacher to do is to facilitate learning. Teachers need to observe many different learning situations and to put into practice what they have learned by working with individuals, with small groups, and with large classes of students. Teacher education programs should also provide experiences where the preservice teacher associates with students in both school and community activities so that he can learn about young people and how they learn outside, as well as, inside the classroom.

In the preservice education of teachers, the teacher should have many opportunities to observe good teacher models--"teachers who are effective in stimulating and developing creative inquiry, careful investigative skills, and enthusiastic interest among students with different backgrounds, abilities, and goals" (15, p. 36). He should observe and discuss a variety of individual styles for planning and guiding laboratory experiences, leading discussions, lecturing, advising, and tutoring students.

One basic experience which should be provided the student is the opportunity to work with many different kinds of students representing different cultural backgrounds and levels of ability. This allows him to see that the world is not all like his world.

Guideline nine proposes that teacher education programs foster continued learning in science principles and pedogogical techniques (15).

There are many who believe the development of the ability and persuasion to continue learning is the single most important aspect of science teacher preparation programs (15). The writer will not debate this point here, but suffice it to say that the writer believes continued learning is important.

The Recommendations of the Association for the Education of Teachers in Science (AETS) and the Cooperative Committee on the Teaching of Science and Mathematics

In a 1968 publication (16), the Association for the Education of Teachers in Science and the Cooperative Committee on the Teaching of Science and Mathematics presented four identifiable areas in preservice education programs. These four general areas are: (1) the school as a social institution, (2) the characteristics of learners and the conditions of learning, (3) the understanding of teaching methodology, and

(4) practicum type experiences which include such activities as observation of intern teaching.

The AETS (16) presented a discussion of three possible approaches to science education. How professional education is "packaged" depends upon the philosophy of the professional and administrative staff of the institution. The three possible approaches identified by AETS are presented below.

The Traditional Approach. The traditional approach has been the "discipline" approach, with specific courses being prescribed. These prescribed courses include educational psychology, history of education, educational methods, tests and measurements, and student teaching.

The Functional Approach. This type of program design refers to the major functions which teachers must perform. An example of this would be the role of communicator. As a communicator, the teacher is regarded to act as a go-between between his discipline and society. Another function is that of instructional leader. In this role, he helps to plan, carry out, and evaluate the learning experiences of his students.

The advocates of this approach design their curriculum around practical experiences which involve designing and implementing curriculum; selection and maintenance of instructional material; making use of new media; constructing tests; handling routine reporting chores; and expressing ethical concepts in an academic environment.

The functional approach views preservice education as a learning experience involving student involvement in "real" situations.

The Competency Approach. This approach to teacher preparation identifies minimum competencies to be acquired before initial employment as a teacher. This approach stresses an understanding of children and adolescents; an understanding of physical and mental development of students; an appreciation of the wide ranges involved in "normal" behavior; an understanding of the influence of socioeconomic status, membership in minority groups, and peer pressure on academic achievement; and the development of instructional materials for a wide range of abilities and interests of students.

The teacher must obtain competencies which will permit him to achieve the purposes which society says he must achieve to maintain society's schools. As a science teacher he has obligations beyond those of other teachers. He must be able to understand and communicate the implications of the interactions of science and technology. A successful teacher must be aware of the many political, economic, and social forces which have had, and continue to have, influence on schools. A program of preparation for the prospective teacher must provide for insight into these forces to enable the teacher to interpret and utilize them in his efforts to prepare students for effective participation in his role as a participant in society.

The competency approach involves minimum competencies in the teaching act. These include the "why" and "how" of teaching methods. He must be technically proficient in the day-to-day tasks of teaching. These proficiencies include setting realistic goals for himself and his students, realization of the level of maturity and understanding attained by students, careful and thorough planning of learning situations, developing skills in student motivation, making assignments, providing practice for student learning, and maintaining appropriate discipline.

As indicated earlier, which method is employed depends upon the philosophy of the institution conducting the preprofessional education of teachers. Many programs incorporate ideas from each approach, thus cannot be classified as one or the other. Perhaps a program which integrates the best ideas of each approach would be the most successful approach to teacher education.

Finally, the AETS (16) believes that the teacher must serve as a professionally competent person, exhibiting characteristics which are consistent with professional service and manifest pride and satisfaction in teaching.

Thoughts of Boener, Uhlhorn, and Shimer on Preservice Education (4)

These authors are in agreement with the preservice needs already expressed in this review. They ask the most obvious question, "Can all these needs for science teaching be fitted into a two or three semester hour methods course?" The obvious answer is "no!" But what are the alternatives? They offer the following synopsis of the answer to this question:

1. Institutions should offer fewer general courses in the theory of learning, educational psychology, child development, the theory of test construction, curriculum, and the history and philosophy of education.
2. Institutions should offer more comprehensive courses related specifically to science methods and laboratory techniques.

Boener, Ulhorn, and Shimer (4) believe there are advantages in preservice educators "getting involved" in planning, preparing and teaching a secondary school science class. Among the advantages to this type of experience for the preservice educator are:

1. The student would have opportunity to discover motivational or instructional material.
2. The student can experience the activities built into preparing for laboratory activities which force him to make decisions concerning:
    a. the best arrangement of work stations
    b. the equipment needed and/or the possible use of substitute materials
    c. Means of collecting, distributing, and obtaining equipment
    d. laboratory management
    e. methods of determining the worth of the laboratory experience
3. This experience gives him opportunity to survey audio-visual materials, including possible misuse of these materials.
4. This experience allows him to exchange ideas and experiences of his college classmates who may have participated in this activity with him.

In addition, methods and techniques classes described by the authors (4), although emphasizing practical experiences, could provide an overview of the current trends and available sources for science curriculum, facilities, equipment, testing and research, and could provide an understanding of the interrelatedness of all science and general education.

Summary of Preservice Education of Science Teachers

If teacher preparation is to meet the demands of the AAAS *Guidelines* (15) and the AETS *Guidelines* (16), then education of science teachers must change from the present status. The present status is one which has changed little over the years. We are still preparing teachers to be discipline oriented, while developing new curricula which are multidiscipline oriented and self-instructional. What a paradox!

It should not be gleaned from the preceding discussion that all prior efforts in teacher education have been failures. Rather, because of the pressures being exerted on the profession and the concerns that the public, teachers, and the teacher educators have for improving the profession, the period ahead should be most exciting and challenging (34). Those who are in the teacher preparation business should not panic but should look forward to shifting their orientation to increased concentration on the development of new and exciting programs.

Thus, it should be reiterated that the pressures on present-day education of teachers that will cause it to decline are good. They are good. They are good because they will elicit change. As most science teachers realize, change is one of the most powerful scientific concepts (39). The serious challenges facing science education rationale cannot be met within the framework of the existing curricula (20).

Inservice Education

What Is Inservice Education?

Inservice education may take place any time--either as full-time or part-time study--during the professional life of the teacher. In-service education may consist of carefully planned, continuous class work over a long period of time leading to an advanced certificate, diploma, or higher degree. It may also be casual study, done irregularly in the evenings or during vacations.

Johnston (27) believes that inservice education is an essential element of a teacher's professional career. Johnston (27) admits that some teachers, even where law requires it, have never conscientiously followed a course of inservice study.

The Need for Inservice Education

The growing pressures for more effective teaching has paralled the increasing complexity of our changing society. Some of these pressures have come gradually; others have come suddenly and follow very closely the national and international developments of our time.

Knowledge has grown rapidly during recent years. It continues to grow at an ever greater pace. The race between education and possible catastrophic events has never been so closely run. Some believe it now appears certain that injustices to children and youth will be inevitable unless education for teachers increases in quality and quantity, both before and after one begins to teach (31).

The experienced and the beginning teacher, the good and not-so-good teachers, all need to extend their knowledge and change their patterns of teaching as research reveals specific needs (7). Not only is more now known in subject matter areas, but curriculum adjustments are many and constant. No teacher has the right to be an educational island and remote from modern school innovations (22, 31).

Purposes of Inservice Education (27, 31, 7)

Extension of Knowledge. This is an important aim of much of inservice education. Most teachers cannot continue full-time study following the first degree. To gain knowledge needed for greater effectiveness in teaching, they must attend classes on an inservice basis. With the rapid increase in knowledge, teachers have found it necessary to increase their horizons through this mode of education.

Consolidation and Reaffirmation of Knowledge. This is closely related to the above purpose. New teachers sometimes search for support when they find themselves working in a school in which the majority of their colleagues demonstrate that they are unfamiliar with "new" knowledge and that they despise "modern" innovations (41).

Regular Acquisition of Knowledge. Johnston (27) believes this type is limited mostly to education courses. Since the NSF has reduced financial support for teachers, a drastic decline in summer school attendance has been observed in the sciences. Johnston (27) further believes that special cycles of courses should be set up whereby the inservice teacher may be exposed, on a regular basis, to new developments in chemistry, biology, physics, and science education. Graduate education courses are already in existence in almost any college which trains teachers as a part of its program.

Acquaintance with Curricular Developments. Johnston (27) states that this specific purpose has become particularly important since 1960, and will probably increase in importance in the last quarter of this century.

Educational foundations, depending for their financial support on industrial giants, have also created conditions which have led to curricular reform. Although educators have had curricular changes in mind for years, it was not until money was available to make the studies, that the studies began.

Watson (41) believes that improving education through inservice programs that cover new curricular materials appears to be a professional obligation.

Acquaintance with Psychological Developments. Moffitt (31) and Johnston (27) believe that the present "Piaget-dominated" era has done a great deal to improve curriculum development. Teachers should become familiar with Piaget's developmental level because of the conviction that a child can learn something only when he is ready, so is the feeling of Piaget (21). And that to be ready, one must go through his maturation process. Once teachers learn that certain things can't be learned until a certain developmental level has been reached, much improvement can easily be made.

Acquaintance with the Sociological Basis of Education. The work of the new sociologists is making a fresh impact on both preservice and inservice courses for teachers. Johnston (27) believes that improvement in technique and in effectiveness has been much more successful than some of the earlier achievements already mentioned. Many of the new educational sociologists are in chairs and in positions of importance from which it should be possible for them to influence the whole service of education.

Acquaintance with Principles of Organization and Administration. Johnston (27) states that little effective work on school organization and educational administration can be profitably attempted in preservice courses. It is only after some service experience that the practicing teacher picks up a casual on-the-job familiarity with the principles of organization operating in the area in which he works. Teacher acquaintance with administrative problems should lead to greater cohesiveness between teacher and administrator.

Repetition or Extension of Original Preservice Education After Intervals, i.e. Positive Retraining. This purpose is particularly important for teachers of certain skills. Army, navy, and airforce instructors in all ranks have imposed upon themselves regular recurrent training. In civilian education, many educators return to school during the summer to gain positive retraining or positive reinforcement.

An important feature of this kind of course is its regularity. The appreciation of the value of the regular recurrence of inservice opportunity appears to be clearly accepted in the work of Teachers' Refresher Course Centers throughout the Soviet Union (29). Everybody, however, does not recognize the need to regularly "recharge the batteries" of the teaching profession.

Conversion Courses. Courses referred to in this paragraph owe their name to the military practice of training aircraft pilots by "converting" them from one type of aircraft to another. Conversion courses for teachers are a fairly recent development. In general "conversion" courses the plan is to "convert" teachers from work with children at one stage of education, or of one age, to the somewhat different work of teaching children at another stage or of a different age.

Acquaintance with New Aids. Johnston (27) states that the last three decades have shown a more rapid development of new teaching aids and their use than ever before in the whole history of education. The technological revolution, especially in electronics, has made this possible. Programmed materials, closed-circuit television, 8 mm cassette-loaded projectors, overhead projectors, polaroid cameras, television and radio, and tape recorders are only a few of the aids that teachers may learn about with profit.

Understanding the New Relationship between Teacher and Student. Long or short-term institutes have been created to deal with this type of inservice education. The new methods are explained and teachers are given the chance to perform "hands on" activities to become better acquainted with the new methods.

Acquaintance with and Participation in Educational Research. Many teachers believe that the split is complete between teachers of education and educational researchers. Teachers feel that they have a joint function to discharge: firstly, they would like their teaching to reflect the most recent conclusions established by research, and, secondly, they would like to participate in research or in field investigation. Inservice facilities may well have the purpose of acquainting teachers with research developments and also of affording them opportunities to participate in organized research.

Forms of Inservice Education

Johnston (27), and Moffitt (31) describe several forms of inservice education. The following list and discussion constitute a summary of these authors' views:

1. Correspondence Courses: Many teachers spend their working days totally enveloped in schoolwork, or they live in remote areas relatively inaccessible as far as higher education is concerned. These teachers, and many others can profit from

correspondence.

2. Single Lectures (seminars): These lectures are usually done by authorities in a particular field. Following the lecture, a question-answer period usually takes place. There are many things which may be obtained by the lectures and ensuing questions.

3. Informal Activities: Groups or individuals interested in inservice education may provide accommodation and leadership for meetings of groups of teachers interested in some professional problem or an aspect of educational research. This work may be under fairly loose direction and may lead to a series of occasional rather than regular meetings. As long as participants engage in planning the activity and continue to take part in it, maintain contact by correspondence and attendance at arranged meetings, this is a profitable form of inservice activity for some teachers.

4. Conferences: Conferences have very irregular time limits. Conferences may range from one-half day to several days, even weeks. Much opportunity for exchange exists in most conferences.

5. Short Week-End Courses: A course is usually more formal and informational than a conference. This is a special place selected for dissemination of a specific amount of material. While some conferences are mandated, most courses are not.

6. Short Evening Courses: This is particularly good for those teachers unable to have school time to participate in inservice education in other ways.

7. <u>Short Courses During School Time</u>: Day-release arrangements and the sandwich principle have arrived as devices to provide additional opportunities in the big world outside. Although this trend doesn't have much of a hold in the United States, it is prevalent in the United Kingdom.

8. <u>Extension Courses</u>: These courses are taught by educators from major state institutions who travel to a central locality. Teachers then travel, usually a short distance, to the locality and receive college lecture education.

9. <u>Summer School</u>: Most inservice education occurs during the summer when public schools are not in session. Teachers in summer school attend for a variety of reasons.

10. <u>Extended Full-Time Education</u>. Most larger systems extend to their teachers the possibility of taking a one year leave of absence to attend school on a full-time basis. Some states even have sabbatical leaves for teachers.

11. <u>Television Courses</u>: As technology increases and as costs decline, there will be a greater number of television "talk-back" courses being taught. These courses result in minimal travel for participants, but allows them to communicate directly with the instructor and fellow "classmates."

Rationale for Secondary Science Course Content

Teachers and students have been dissatisfied with schooling for some time (19). A flood of books has poured into the American market criticizing the organization, management, and especially the curriculum of schools. Several common themes run through the criticisms of schools and education in these books: the need to recognize young people as individuals; the importance or an education that deals with the realities of contemporary life; the demand that a greater range of learning options in the curriculum be offered; the necessity for participation by the students themselves, in planning and choosing how they shall learn; and the serious need to enhance the satisfactions of teachers by creating new roles for them in their relations with young people. The large number of titles and the enormous sale of such books criticising education suggest widespread discontent on the part of parents and other citizens with school programs (8, 19).

Much attention is being paid to studying just what students want and need to know. The past forty years of study in developmental psychology has led to a recognition that children, adolescents, and adults think differently from one another (21, 30). They respond to different kinds of data and have different ways of processing it. Adults can no longer dictate entirely a young person's school curriculum as they have done in the past. This dictation has resulted in the students being unable to connect their lives in school with life outside the school (41).

Besides the irrelevancy that seems to characterize much of the school curriculum today, the cultural revolution has called for new curricula (19, 14, 23, 26, 20, 28). The magnitude of this transformation in Western civilization are thoughtfully considered in a number of important publications. Willis Harman suggests that since the Middle Ages, Western civilization has been dominated by what he calls the "Industrial State Paradigm" (19). The pattern of thought that emerges is characterized by:

1. The development and application of scientific method
2. The molding of scientific and technological advance
3. Division of labor leading to industrialization
4. Technological and economic growth and progress
5. Man attempting control over nature
6. The drive to accumulate wealth

Harman points out that the "Industrial State Paradigm" has been responsible for the fabulous products of modern industrial organization and modern technology. But trouble is in the air, for industrial success underlies all the serious social problems of our day (19).

Harman (19) indicates that the successes of the technological era have resulted in problems that cannot be solved with efficiency within the system of thought creating the successes. Replacement of manual and routine labor by machines has led to increased unemployment. Advances in communication and transportation have led to urbanization, which produces a complex society that is especially vulnerable to both natural and deliberate breakdown. Increased efficiency has been accompanied by dehumanization of the world of work. The growth in the power of systemized knowledge has resulted in threats to privacy and to freedoms with the creation of surveillance technology and bioengineering. Increased affluence has brought about an increase in the individual's impact on the environment, as well as an increase in pollution and in energy requirements (19).

The purpose of education should be to enable us to process, handle, interpret, employ, organize, and select from the many bits of raw data surrounding us (19). The tendency of the schooling system is often exactly opposite from what it should be. Education very frequently degrades significant ideas, conceptions, skills, and statements of capacity (19). It has always been tragic that so much time and effort has been devoted to learning simple assertions of fact. But, until recently, there was fairly general agreement on a fairly limited set of facts as being THE important ones for a given group of students to learn. Now, we are faced as teachers and as students, with an increase in the number of facts, the number of subjects, the number of ideas, which are presented to us as important (19).

The knowledge explosion has not, of course, produced a corresponding increase in the capacity of the human organism to absorb, process, interpret, and understand information. We focus with pride on the numerous bits of information which are available to us, but we do not pay attention to the lack of our ability to look upon these as meaningful bits of information. It is desirable, when in an attention-poor world, to increase our own and our students' capacity to pay attention (19, 40, 20, 18).

Knowledge from observation, from society, and from studies on human development, suggest that an entirely new curriculum is needed. A new curriculum which is new in subject matter, new in its approach to learning, new in its conception of the student, new in the role of the teacher, new in the role of the disciplines and newness in the structure of the curriculum (19).

Designing a multidisciplinary curriculum that will consider developmental characteristics of young people in a rapidly changing social context demands the formulation of a new theoretical base (10). This conclusion may seem presumptious, and should be accepted with some reservations. However, consider existing curricula. They are very presumptuous and are inconsistent with knowledge of human development. Authorities believe that new curricula must be formulated as tools for developing all manner of thought processes. Most science curricula are organized in logical subject matter topics that reflect a choice of selected elements of the discipline. Materials are designed to motivate the student and stimulate understanding of the subject matter, but do they do that? In a sense, the student's concerns and development are "second-fiddle" to the subject matter organization. Various degrees of simplification occur, and the simplified material is constantly studied to see if it can be "watered down" even more. Curricula arranged in logical subject matter topics impose critical responsibilities on curriculum materials. When materials fail to motivate or interest the student or when he fails to learn, the responsibilities for failure are variously assigned to teachers, to students, and to parents (19). It is suggested that the theoretical base of traditional education produces failures as a consequence of its assumptions (21). No amount of reform can eliminate student failure within this framework.

A curriculum invention that is to provide a different organization for learning and for teaching must be accompanied by a newly developed theoretical base, or program rationale. Numerous attempts to introduce multidisciplinary curricula into schools have failed, partly because criteria for traditional curricula were applied in judging their quality (19).

In order for multidisciplinary programs to possess relevance as related to students' needs and desires, and to stimulate interest, the new curricula being produced, and yet to be produced, must:

1. relate to physical, mental, psycho-social, and moral developmental levels of the students being taught.
2. allow students to select the topics he desires to study, and provide a variety of activities to accompany his selection.
3. present problems, but also afford many activities designed to solve the problem.
4. provide such a wide range of activities that each student will derive benefits from the curriculum.
5. focus on student problems and concerns, providing concepts and principles relevant to these problems and concerns.
6. allow the students input related to their personal and social experiences.
7. provide activities which accent Piaget's developmental levels.
8. limit problem areas to those of greatest relevance to existing societal structure.
9. provide a variety of experiences utilizing as many elements of society as possible.
10. provide activities which allow students to interact with people of all ages in the community.
11. provide opportunity for students to democratically participate in classroom management.

The developers of new curricula should develop them such that the curricula provide experiences that will facilitate the eventual ability of students to:

1. learn the principles of learning so that they can learn independently throughout their lives.

2. recognize problem areas; see that problems may be solved in more than one way; to realize many problems may be too difficult to solve in a simple way.
3. look critically at bio-social issues.
4. approach controversial issues in a rational manner, analyzing them according to clarified values.
5. creatively utilize their emotions, values, and intellects.
6. understand man as a social and biological being having to interrelate with all elements of the environment.
7. explain and interpret phenomena, but with great care.
8. use the process skills in solving many problems related to the student.
9. develop interest in and concern for the future.
10. recognize the potentialities and limitations of science.
11. encourage individuality, but not at the expense of others.

The Individualized Science Instructional System Program, still in development and piloting, appears to fulfill, at least to a major extent, the desires of many leaders in science education.

ISIS and Contemporary Thought

"To escape the threat of obsolescence, education in the sciences must be based upon the kind of information that has survival value and upon strategies of inquiry that facilitate the adaptation of knowledge to new demands" (22, p. 31). "Because science and the cultural scene are in a continuous process of change, the content of science courses must be constantly reevaluated and, if necessary, revised to reflect major shifts in thinking and new interpretations of phenomena"

(22, p. 34). The preceding quotations from Paul Hurd show that science education has a number of responsibilities. One of them is to survey the passing scene in science and in education in order to caution the overextended, stimulate the undercommitted, and to call attention to the areas that need more stress (26). Scientists and science educators have for many years debated which of the major ideas in science should make up the core of school science. Are some principles, laws, and theories so vital that every student should understand them? (26). If so, there is no agreement about which ones. What critical problems are within the grasp of elementary, junior and senior high school inquiry? Are such contemporary problems as insecticides, automobile safety, and pollution of air and water likely to be suitable? The developers of the Individualized Science Instructional System (ISIS) program think so. To demonstrate their deep conviction about such contemporary thought, they are developing a complete program of instruction to meet the changing times. The remaining portion of this literature review will center around goals, methods, and objectives of science as seen by science educators, with comments on how ISIS has determined to meet these challenges.

Thoughts on Science Education

Jacobsen (26) sees Rachel Carson's book Silent Spring as posing three implications for science educators as they work with young people:

1. We must help our young people develop scientific literacy. Future citizens should be able to read and comprehend such books as Silent Spring (a story depicting effects of water pollution).

2. This example (<u>Silent Spring</u>) shows that young people need to possess the concept of interrelatedness of different forms of life and the physical environment. When we change our environment, we can expect a variety of effects.

3. The example points out the danger of acting before considering the possible consequences and the pitfalls that are inherent in a doctrinaire approach to these issues. Perhaps our young people should have the experience of approaching some of these issues, digging out the facts, evaluating claims and counter-claims, and deciding what they think should be done.

If our future citizens are to be equipped to cope with problems of the kind highlighted by Miss Carson, what kind of education will they need?

Alan T. Waterman (40) indicated that it is imperative that we use the new forces of science and technology wisely and has suggested that education is the path toward integration of science and society. Capital discoveries are just beginning and continued progress will raise issues of significance. Whether future developments enable man to have great power over nature's resources, influence or control over life or over men's minds, or take strides in space travel, they will certainly create problems of such concern to the human race that all mankind will have no choice but to cooperate in the solution to problems created by technology.

> It follows, too, that a public awareness of science and its implications is of the utmost importance. We have an obligation not only to train the scientists that our society requires but to make sure that the entire school population is at least literate in science, and has some appreciation of the forces that are shaping our world. The establishment of scientific literacy must begin in the earliest grades and continue through the highest levels of education. The scientific

> revolution has overtaken the present generation of adults--taken it by surprise, as it were--but much can be accomplished through vigorous and imaginative programs. Tomorrow morning, pick up your newspapers and note how many headlines relate in some way to the impact of science and technology upon our lives. Can we afford to ignore or fail to understand the forces that are doing so much to shape our future and the future of our children (40, p. 23).

Dupre and Lakoff (8) call for public understanding of scientific endeavors. If the public does not understand the new partnership between technology and society, it will be unable to cope with the problems created by the new partnership.

By the close of World War II it was evident that the U. S. had changed from an agrarian society to a scientific-technological society, from rural to metropolitan communities, and in many ways our pattern of life and philosophic values have changed. The demand for women and men trained for technical jobs has increased tremendously. But the science curriculum has remained fairly static despite the new curricular programs developed since 1960. Now there are newer programs being developed which help young people integrate and interrelate to societal changes.

Paul Hurd (21) believes American schools need a science curriculum suited to recent advances in science and to a changing society. Our schools require courses designed to prepare young people for change and progress and to help them meet the problems they will face during their lifetimes. A rapidly changing society stimulated by advances in science demands an educational program designed to meet the challenge of change. This philosophy is brought to a high pennacle in the ISIS program.

Hurd (22) further believes that our society changes very rapidly, calling upon individuals to adapt or fail to survive. This means that an education in the sciences must be based upon the kind of information that has survival value and upon strategies of inquiry that facilitate the adaptation of knowledge to new demands. Hurd (22) believes, what is more important, it should provide young people with the background and intellectual talents for shaping the future in a manner that assures the welfare of human beings and sustains progress. Education in the sciences should be oriented to lifelong learning, rational and independent thinking, and the acquisition of productive knowledge. Hurd goes on to say that

> a curriculum is needed that is oriented toward a 'period' not yet lived, influenced by discoveries not yet made and beset with social problems not yet predicted. The need is for an education designed to meet change, to appreciate the processes of change, and to influence the direction of change (22, p. 30).

Much thought, time, energy, and money must be put forth to incorporate all of the suggestions already mentioned into a science program. ISIS is attempting to put many of these resources together and produce an exciting program.

Thoughts on Inquiry Learning

William Kesson (28) believes there is joy in the search for knowledge. He further believes that the first task and central purpose of science education is to awaken in the child, whether or not he will become a professional scientist, a sense of joy, the excitement, and the intellectual power of science. While Hurd (21, 22) and Jacobsen (26) don't stress joy and excitement, I believe joy and excitement plus scientific competency should be interrelated in a science education program. If either of these elements are removed, a miserable science education program results. Kesson (28) believes that science is more than a body of facts, a collection of principles, and a set of machines for measurement; it is a structured and directed way of asking and answering questions. Kesson sums up his feelings in the following quote:

> . . . it is a structured and directed way of asking and answering questions. It is no mean pedagogical feat to teach a child the facts of science and technology; it is a pedagogical triumph to teach him these facts in their relation to the procedures of scientific inquiry. And the intellectual gain is far greater than the student's ability to conduct a chemical experiment or to discover some of the characteristics of static electricity. The procedures of scientific enquiry, learned not as a canon of rules but as ways of finding answers, can be applied without limit. The well-taught student will approach human behavior and social structure and the claims of authority with the same spirit of alert skepticism that he adopts toward scientific theories. It is here that the future citizen who will not become a scientist will learn that science is not memory or magic but rather a disciplined form of human curiosity (28, p. 21).

The discipline of scientific enquiry demands respect for the work of the past together with a willingness to question the claims of authority (28). The attitude of "intelligent caution," the restraint of commitment, the belief that difficult problems are always susceptible to scientific analysis, and the courage to maintain doubt will be learned best by the student who is given an honest opportunity to try his hand at scientific enquiry (28). A very important point made by Kesson is that for scientists, young people, and adults, novelty is permanent; scientific enquiry continually builds novelty into a coherent design, which is full of promises and reduces our terror and satisfies for a while the human desire for simplicity (20). ISIS is attempting to combine scientific content with a great deal of novelty. If Kesson is correct in his teachings, then ISIS is destined to become one of the most influential science programs yet developed.

The best lessons of an experiment or teaching activity are taught only to the student who is actively engaged in the equipment and procedures of a laboratory. Facts without meaningful experiences are useless to the student (22). ISIS puts facts plus novelty into its program. The students continually are involved with "hands on" activities which make facts meaningful and useful.

Thoughts on Scientific Knowledge

The facts and principles of science change with each advance in our understanding of the world. For this reason, it is difficult to forecast with accuracy what scientific content the student should know. Nonetheless, it is possible to sketch in outline the scientific knowledge the educated student should have:

1. Scientific history--a basic knowledge of some of the greatest events occurring in science throughout recorded history.
2. Astronomical knowledge--the universe, its galaxies, our solar system, the earth, and its immediate environment.
3. The structure and reactions of nature from the smallest particles to their combinations in minerals and rocks; elements, compounds and mixtures, large and small molecules, atoms, protons, neutrons, and electrons.
4. The conservation and transformation of energy; the electromagnetic spectrum, energy of motion and potential energy, electrical energy and chemical energy; force and work, gravitational and magnetic fields.
5. The interaction between living things and their environment, animal and human behavior, the relation between biological structure and function, reproduction, development, genetics, evolution, and the biological unit-cell, organism, and

populations.

Teaching is exchange between people. The student can understand only what he has been prepared to understand, the teacher can teach only what he knows, and the meeting of the prepared student with skillful teacher is an unforgettable encounter for both of them (28).

Summary and Conclusion of Literature Review

Literature bares out the fact that the primary goal of science instruction is to help the students gain some conception of how they can deal with important issues related to science and technology.

The best summary that could be presented is given by Jacobsen:

> There are some who will say that this kind of education is controversial and dangerous. It is! But our young people will live in a tough-minded world, and they must be equipped to live with controversy. Good education has always been dangerous. The timid shrink from it, and the autocratic fear it. We can only hope that our students will not be timid and that the autocrats will continue to fear them.
>
> I realize that there are those who will say, 'But this is social studies.' My rejoinder is that I wish it were social studies, for there are many other matters that could occupy the science educator. However, I don't believe that our children and young people are being adequately prepared to deal with issues related to science and technology in the democratic fashion necessary in a free society. It is essential that the teacher who helps prepare young people to deal with these issues have some understanding of the major ideas and the methods of investigation of the sciences. As pleasant as it might seem, I do not think we should ever wash our hands of this responsibility (26, pp. 23-24).

We must know what our teachers do not know in order to develop adequate preservice and inservice teacher education. Once our teachers are properly educated, then we can proceed with the process of developing critical students of science and technology.

CHAPTER III

RESEARCH DESIGN

Introduction

"Science never professes to present more than a working diagram of fact. She does not explain, she states the relations and associations of facts as simply as possible" (4, p. 4).

Such is the nature of this research design. In effect, it sets the rules which guided the study and prescribes the manner in which outcomes shall be presented and interpreted.

Instrument

The instrument used in this study was composed of factual style multiple choice questions covering eight of the 10 minicourses available from ISIS. The eight ISIS minicourses test booklets contained 236 questions. Eight questions were randomly selected from the available questions covering each unit. The 64 questions selected were sent to 15 science specialists who acted as judges. These individuals were selected on the basis of their teaching specialty. These individuals were asked to select four of the eight questions on each minicourse which they judged would give the best indication of a teacher's factual knowledge of the scientific principles contained in each of the eight minicourses. All 32 questions in the instrument were selected by at least 10 of the 15 judges. Each of the judges was asked to make any revisions of test items that they felt were needed. A few minor revisions were made (see Appendix E).

Selection of the Secondary Science Teacher Sample

A list of the secondary science teachers in Oklahoma was obtained from the Oklahoma State Department of Education. This list contained 1,897 names.

A letter (see Appendix A) was sent to all 1,897 teachers. This letter explained the purpose of the study and contained a postage-paid return card (see Appendix D). The teachers were asked to return the card if they were willing to participate in the study. One hundred fifty-three cards were returned.

An attempt was made to contact all of those returning the participation cards. However, because of various reasons, only 130 were personally contacted by the writer. Those contacted confirmed their willingness to participate.

Personal data concerning teachers' professional activities was collected. This data was used in analysis of findings.

Data Collection Procedures

The writer contacted the 130 respondents to the initial mail-out. Arrangements were made for the writer or the respondents' administrators to administer the diagnostic instrument to the teachers. The writer personally collected 26. A time limit of 30 minutes was imposed. One hundred four were sent by mail to administrators who assisted the writer in the administration of the diagnostic instrument. A letter, giving instructions to the administrator (see Appendix B), accompanied the instruments. Eighty-six of the mail-outs were completed and returned by mail. The mail-out and personal collection procedures netted 112 completed instruments.

The instrument was scored on the basis of right or wrong responses to each of the 32 questions. Questions which were not marked by the respondents were scored as incorrect.

CHAPTER IV

RESULTS

Overview

A total of 112 respondents were included in the analysis of the data. This number was used to compute the percentage of responding population correctly answering the 32 questions on the diagnostic instrument (Table I).

The percent of the responding population correctly answering questions ranged from 22 percent correctly answering question 27 to 96 percent correctly answering question 22. Some questions were answered correctly by as few as 25 of the 112 respondents.

The minicourse represented by each question is also included. For detailed analysis of the percentage scores on each minicourse, see Tables III through IX, and especially Table II.

Overview of Minicourses and Percentages of Questions Correctly Answered

Table II is perhaps the most revealing of all the tables in this chapter. The percentages in Table II were obtained by dividing the total number of correct responses by the total possible correct responses on each minicourse. The total possible correct answers amounted to 448 for each minicourse. This number was arrived at in the following way: there were 112 total respondents; each minicourse had four

TABLE I

NUMBER OF TIMES EACH QUESTION WAS CORRECTLY ANSWERED BY POPULATION SAMPLE

Questions	Percent of Population Correctly Answering Question	Number of Times Question Correctly Answered	Minicourse Represented by Question
1	85	95	"Gut Reactions"
2	54	60	"The Generation Link"
3	60	67	"Packaging Passengers"
4	78	87	"Heart Attack"
5	89	100	"Getting Enough Oxygen"
6	71	80	"Things That Last"
7	84	94	"Things That Last"
8	86	96	"Buying and Selling"
9	29	32	"The Generation Link"
10	45	50	"Gut Reactions"
11	33	37	"The Computer Age"
12	36	40	"The Computer Age"
13	85	95	"The Generation Link"
14	87	97	"The Computer Age"
15	38	40	"Getting Enough Oxygen"
16	92	103	"Buying and Selling"
17	56	63	"Packaging Passengers"
18	63	70	"The Generation Link"
19	33	37	"The Computer Age"
20	29	32	"Gut Reactions"
21	69	77	"Packaging Passengers"
22	96	108	"Gut Reactions"
23	93	104	"Buying and Selling"
24	81	91	"Buying and Selling

TABLE I (Continued)

Questions	Percent of Population Correctly Answering Question	Number of Times Question Correctly Answered	Minicourse Represented by Question
25	50	56	"Things That Last"
26	61	68	"Heart Attack"
27	22	25	"Things That Last"
28	36	40	"Packaging Passengers"
29	40	45	"Getting Enough Oxygen"
30	94	105	"Heart Attack"
31	80	90	"Getting Enough Oxygen"
32	84	94	"Heart Attack"

possible correct responses; multiplying 112 by 4 gives the number 448. The total number of correct responses on each minicourse was then obtained from tabulated data.

TABLE II

PERCENT OF TOTAL POSSIBLE CORRECT RESPONSES ON EACH MINICOURSE CORRECTLY ANSWERED BY RESPONDENTS

Minicourse	Percent Correctly Answered
"Things That Last"	56
"The Computer Age"	47
"Buying and Selling"	88
"Packaging Passengers"	55
"Heart Attack"	79
"Getting Enough Oxygen"	61
"The Generation Link"	60
"Gut Reactions"	66

The highest percentage of correct responses occurred on minicourse "Buying and Selling," where 90 percent of possible correct answers were answered correctly. The lowest percentage of correct responses occurred on minicourse "The Computer Age" where 47 percent of the possible correct answers were answered correctly.

The scores on four of the eight minicourses reveal that less than

60 percent of the possible correct answers were correctly answered. Two of the remaining four minicourses were near the 60 percentage mark. Only two of the eight minicourses had percentages greater than 70 percent of the possible correct answers answered correctly.

Minicourse "Things That Last"

Question number 27 on the diagnostic instrument was correctly answered by 25 of the respondents; 22 percent of the respondents answered this question correctly. Question 7 on the instrument was answered by 84 percent of the respondents.

The average percent of correctly answered questions on the instrument from this minicourse was 56. (See Table III.)

TABLE III

NUMBER OF TIMES QUESTIONS OVER MINICOURSE "THINGS THAT LAST" WERE CORRECTLY ANSWERED

Instrument Question	Number of Respondents Correctly Answering Each Instrument Item	Percent of Respondents
6	80	71
7	94	84
25	56	50
27	25	22

Minicourse "The Computer Age"

This minicourse had the greatest number of incorrect answers. As many as 67 percent of the 112 respondents incorrectly answered questions from this minicourse. In fact, greater than 64 percent of the respondents incorrectly answered three of the four questions over the minicourse.

The average percentage of correct responses on this minicourse was 47. (See Table IV.)

TABLE IV

NUMBER OF TIMES QUESTIONS OVER MINICOURSE "THE COMPUTER AGE" WERE CORRECTLY ANSWERED

Instrument Question	Number of Respondents Correctly Answering Each Instrument Item	Percent of Respondents
11	37	33
12	40	36
14	97	87
19	37	33

Minicourse "Buying and Selling"

This minicourse had the lowest percentage of missed questions, amounting to 12 percent of the possible correct answers. (See Table II.) Two of the questions were answered correctly by more than 102 of the respondents. The greatest number of respondents missing a question on this minicourse was 21, representing 19 percent of the responding population.

All questions on this minicourse were answered correctly by more than 80 percent of the respondents. The average number of respondents answering questions correctly was 88%. (See Table V.)

TABLE V

NUMBER OF TIMES QUESTIONS OVER MINICOURSE "BUYING AND SELLING" WERE CORRECTLY ANSWERED

Instrument Question	Number of Respondents Correctly Answering Each Instrument Item	Percent of Respondents
8	96	86
16	103	92
23	104	93
24	91	81

Minicourse "Packaging Passengers"

The highest percentage of respondents answering a question over this minicourse was 69 on question 21. On question 28, 36 percent of the respondents answered this question correctly. The average percentage of respondents answering the four minicourse questions correctly was 55.

Three of the four questions were missed by less than 60 percent of the respondents. (See Table VI.)

TABLE VI

NUMBER OF TIMES QUESTIONS OVER MINICOURSE "PACKAGING PASSENGERS" WERE CORRECTLY ANSWERED

Instrument Question	Number of Respondents Correctly Answering Each Instrument Item	Percent of Respondents
3	67	60
17	63	56
21	77	69
28	40	36

Minicourse "Heart Attack"

The percentage of respondents correctly answering the four questions on this minicourse ranged from 70 percent on question 26 to 94 percent on question 30. The average percentage of respondents correctly responding to questions on this minicourse was 64.

The number of respondents correctly answering questions on this minicourse ranged from 58 to 105. (See Table VII.)

TABLE VII

NUMBER OF TIMES QUESTIONS OVER MINICOURSE "HEART ATTACK" WERE CORRECTLY ANSWERED

Instrument Question	Number of Respondents Correctly Answering Each Instrument Item	Percent of Respondents
4	87	78
26	68	41
30	105	94
32	94	84

Minicourse "Getting Enough Oxygen"

The percentage of respondents correctly answering questions over this minicourse ranged from 36 percent on question 15 to 89 percent on question 5. The average percentage of the respondents answering questions correctly was 61.

The number of respondents answering questions correctly ranged from 40 on question 15 to 100 on question 5. (See Table VIII.)

Minicourse "The Generation Link"

The highest number of respondents correctly answering questions on this minicourse was 89 on question 13; this is equal to 85 percent of respondents. The lowest number of respondents correctly answering a question was 42 on question 9; this is 38 percent of the population.

The average number of respondents answering questions over this minicourse correctly was 60. (See Table IX.)

TABLE VIII

NUMBER OF TIMES QUESTIONS OVER MINICOURSE "GETTING ENOUGH OXYGEN" WERE CORRECTLY ANSWERED

Instrument Question	Number of Respondents Correctly Answering Each Instrument Item	Percent of Respondents
4	100	90
26	40	36
30	45	40
32	90	80

TABLE IX

NUMBER OF TIMES QUESTIONS OVER MINICOURSE "THE GENERATION LINK" WERE CORRECTLY ANSWERED

Instrument Question	Number of Respondents Correctly Answering Each Instrument Item	Percent of Respondents
2	60	54
9	42	37
13	95	85
18	70	62

Minicourse "Gut Reactions"

This minicourse contained the question (number 25) which the greatest number of respondents answered correctly, amounting to 96 percent of the respondents. The range of percentage of respondents correctly answering questions was 29 percent on question 20 to 96 percent on question 22.

The average percentage of respondents correctly answering the four questions on this minicourse was 66. (See Table X.)

TABLE X

NUMBER OF TIMES QUESTIONS OVER MINICOURSE "GUT REACTIONS" WERE CORRECTLY ANSWERED

Instrument Question	Number of Respondents Correctly Answering Each Instrument Item	Percent of Respondents
1	95	85
10	50	45
20	32	29
22	108	96

Personal Data Questions and Performance on Examination

Personal Data Question Number 1: "How many years of teaching experience do you have?"

Seventy-one of the respondents had less than 10 years of experience. Forty-one respondents had greater than 10 years of experience, with only 13 having greater than 21 years of experience.

All of the test averages were somewhere near the population mean score of 65 percent, except for those having greater than 21 years of experience. (See Table XI.)

TABLE XI

NUMBER OF YEARS OF TEACHING EXPERIENCE AND PERFORMANCE ON DIAGNOSTIC INSTRUMENT AS SHOWN BY AVERAGE TOTAL PERCENTAGE*

Number of Years of Teaching Experience	Number in Sample Population	Average Total Percentage for Each Group
0-2	13	66
3-5	34	67
6-10	24	64
11-15	18	70
16-20	12	63
21+	13	58

*Total percentage is the percent of questions respondents answered correctly, assuming 100 percent would mean that all questions were answered correctly.

<u>Personal Data Question Number 2</u>: "How many years have you taught at present school?"

Eighty-six of the respondents have taught in their present school less than 11 years. Only 26 respondents have been at their present school 11 years or more.

The average total percentages for each group of respondents was near the population mean of 65 percent, except for those in the 16-20 years' bracket. (See Table XII.)

TABLE XII

NUMBER OF YEARS OF TEACHING AT PRESENT SCHOOL AND PERFORMANCE ON DIAGNOSTIC INSTRUMENT AS SHOWN BY AVERAGE TOTAL PERCENTAGE*

Number of Years of Teaching at Present School	Number in Sample Population	Average Total Percentage for Each Group
0-2	26	64
3-5	33	68
6-10	27	64
11-15	14	68
16-20	8	58
21+	48	62

*Total percentage is the percent of questions respondents answered correctly, assuming 100 percent would mean that all questions were answered correctly.

<u>Personal Data Question Number 3</u>: "What was your undergraduate major?"

Sixty-six of the respondents were either physical or life science majors. There were approximately twice as many life science majors as physical science majors.

A number of Oklahoma science teachers had an undergraduate major that was something other than life or physical sciences, or math, comprising some 37 of the respondents. The major portion of this group of "other" majors were physical education majors. The next group in this category indicated an undergraduate major in the social sciences. One respondent indicated an undergraduate major in home economics. (See Table XIII.)

TABLE XIII

UNDERGRADUATE MAJOR IN COLLEGE AND PERFORMANCE ON DIAGNOSTIC INSTRUMENT AS SHOWN BY AVERAGE TOTAL PERCENTAGE*

Undergraduate Major	Number in Sample Population	Average Total Percentage for Each Group
Physical Sciences (Chemistry-Physics)	22	65
Life Sciences	44	66
(Biology)	9	
Math	7	61
Other**	37	65

*Total percentage is the percent of questions respondents answered correctly, assuming 100 percent would mean that all questions were answered correctly.

**Included home economics, social studies, and physical education

Information concerning undergraduate minor was not asked for on the Personal Data sheet. However, in subsequent questions, respondents were asked to indicate number of hours in the life sciences and physical sciences. Those in the "other" category did indicate a number of hours in the various sciences, mostly life sciences. (See Table XIII.)

The following hypothesis was tested: There is no significant relationship between a major in the life sciences or the physical sciences and performance on diagnostic instrument.

A two by three contingency table was used to calculate chi square to test the hypothesis. A chi square of 7.815 at the .05 level of significance was needed to reject the hypothesis. The calculated chi square was .18, well below the value needed for rejection. Therefore, the hypothesis was accepted. (See Table XIV.)

TABLE XIV

RELATIONSHIP BETWEEN TYPE OF UNDERGRADUATE MAJOR AND PERFORMANCE ON DIAGNOSTIC INSTRUMENT

Major	Below Average (Below 65%)	Average (65-75%)	Above Average (Above 75%)	Row Total
Physical Science	9 (9.32)*	8 (7.33)	5 (5.3)	22
Biological Science	19 (18.65)	14 (14.65)	11 (10.7)	44
Column Subtotal	28	22	16	66 Total

*The numbers in parentheses are the expected values.

<u>Personal Data Question Number 4</u>: "How many college hours do you have in the physical sciences (includes chemistry and physics)?"

Eighty-three respondents indicated they had between 11 and 50 college credit hours in the physical sciences. Although the spread of hours is broad, these were lumped together because each group average was near the 65 percent population mean.

The group comprising the 51 plus hours of college credit in the physical sciences had a group average of 71 percent. However, only 11 of the 112 respondents were in this category.

Those respondents indicating less than 10 hours of college credit had a group total average of 59 percent. This group represented 18 of the 112 respondents. (See Table XV.)

<u>Personal Data Question Number 5</u>: "How many hours of college credit do you have in the life sciences?"

College hours in the life sciences include general biology, zoology, botany, microbiology, and wildlife ecology. Even though a wide variation of course titles exists, many of the principles basic to each area are also basic to the group as a whole.

Fifty-seven respondents indicated they had less than 30 hours, while 55 had greater than 30 credit hours in the life sciences.

The average percentage of each group is close to the population mean of 66 percent. There was a slight increase in average total percentage for each category as the number of credit hours increased. The only exception is the 62 percent earned by the 31-40 hours' group, a decrease of 2 percent from the 21-30 hours' group. (See Table XVI.)

TABLE XV

NUMBER OF HOURS OF COLLEGE CREDIT IN PHYSICAL SCIENCES*
AND PERFORMANCE ON DIAGNOSTIC INSTRUMENT
AS SHOWN BY TOTAL PERCENTAGE**

Number of Hours in Physical Science	Number in Sample	Average Total Percentage for Each Group
0-10	18	59
11-20	26	65
21-30	34	67
31-40	15	65
41-50	8	66
51+	11	71

*Included physics and chemistry

**Total percentage is the percent of questions respondents answered correctly, assuming 100 percent would mean that all questions were answered correctly.

TABLE XVI

NUMBER OF HOURS OF COLLEGE CREDIT IN LIFE SCIENCES AND PERFORMANCE ON DIAGNOSTIC INSTRUMENT AS SHOWN BY TOTAL PERCENTAGE*

Number of Hours in Life Sciences	Number in Population	Average Total Percentage for Each Group
0-10	13	61
11-20	21	65
21-30	23	64
31-40	19	62
41-50	17	67
51+	19	70

*Total percentage is the percent of questions respondents answered correctly, assuming 100 percent would mean that all questions were answered correctly.

<u>Personal Data Question Number 6</u>: "What is the highest degree you hold?"

Approximately 51 percent of the respondents held a bachelor's degree. Approximately 49 percent held a master's degree or better. Fifteen respondents listed their highest degree in the "other" bracket. All of the "other" degrees were masters in education, except for one Ph.D. and one Ed.D.

The average percentage for each group was close to the population mean of 65 percent of questions answered correctly. (See Table XVII.)

TABLE XVII

HIGHEST COLLEGE DEGREE HELD AND PERFORMANCE ON DIAGNOSTIC INSTRUMENT AS SHOWN BY AVERAGE TOTAL PERCENTAGE*

Highest Degree Held	Number in Population	Average Total Percentage for Group
B.A.	3	67
B.S.	55	63
M.S.	11	68
M.S. + Hours	26	65
Ed.S.	0	0
Ed.D.	2	63
Other	15	69

*Total percentage is the percent of questions respondents answered correctly, assuming 100 percent would mean that all questions were answered correctly.

The following hypothesis was tested: There is no significant relationship between type of degree held and performance on diagnostic tool.

A two by three contingency table was used to compute chi square. A chi square of 7.815 at the .05 level of significance was needed to reject the hypothesis. The calculated chi square was 5.26, below the value needed for rejection of hypothesis. Therefore, the hypothesis was accepted. (See Table XVIII.)

TABLE XVIII

RELATIONSHIP BETWEEN TYPE OF DEGREE HELD AND PERFORMANCE ON DIAGNOSTIC TOOL

Type of Degree	Below Average (Below 65%)	Average (65-75%)	Above Average (Above 75%)	Row Total
Bachelor	28 (28.49)*	19 (14.50)	11 (15.02)	58
Master and Above	27 (26.90)	9 (13.69)	18 (13.98)	54
Column Subtotal	55	28	29	112 Total

*The numbers in parentheses are the expected values.

<u>Personal Data Question Number 7</u>: "What is the number of years that have elapsed since attending a college level class as a student?"

One hundred eleven respondents indicated they had attended a college course as a student in the last 10 years. Seventy-four of the 112 respondents had attended college within the last two years. One hundred respondents had attended a college class within the past five years. (See Table XIX.)

<u>Personal Data Question Number 8</u>: "What is your age?"

Approximately 40 percent of the responding population indicated an age of less than 30 years. Seventy-six of the 112 respondents were less than 40 years of age. The 61 plus age group had four respondents.

Most of the average total percentages for each age group were near the population mean of 65 percent of questions on diagnostic instrument answered correctly. The only exception was the 61 plus group, which averaged 56 percent of correct answers on the instrument. (See Table XX.)

TABLE XIX

ELAPSED TIME SINCE ATTENDING A COLLEGE LEVEL CLASS AS A STUDENT AND PERFORMANCE ON DIAGNOSTIC INSTRUMENT AS SHOWN BY AVERAGE TOTAL PERCENTAGE*

Elapsed Time in Years	Number in Population	Average Total Percentage for Group
0-2	74	66
3-5	26	64
6-10	11	62
11-15	0	0
16-20	0	0
21+	1	55

*Total percentage is the percent of questions respondents answered correctly, assuming 100 percent would mean that all questions were answered correctly.

TABLE XX

AGE OF RESPONDENT AND PERFORMANCE ON DIAGNOSTIC INSTRUMENT AS SHOWN BY TOTAL PERCENTAGE*

Age in Years	Number in Population	Average Total Percentage
20-30	45	67
31-40	31	64
41-50	18	66
51-60	14	61
61+	4	56

*Total percentage is the percent of questions respondents answered correctly, assuming 100 percent would mean that all questions were answered correctly.

<u>Personal Data Question Number 10</u>: "What is the approximate population of the city in which you teach?"

The number of respondents was representative of the distribution of teachers statewide. (See Table XXI.)

TABLE XXI

POPULATION OF CITY IN WHICH RESPONDENT TEACHES AND PERFORMANCE ON DIAGNOSTIC INSTRUMENT AS SHOWN BY TOTAL PERCENTAGE*

Population of City	Number in Population	Average Total Percentage
Under 10,000	57	66
10,000-20,000	10	71
20,000-75,000	26	63
Over 75,000	19	62

*Total percentage is the percent of questions respondents answered correctly, assuming 100 percent would mean that all questions were answered correctly.

CHAPTER V

CONCLUSIONS AND DISCUSSION

Summary of Study

The purpose of this study was to determine Oklahoma secondary science teachers' factual knowledge of scientific principles contained in eight ISIS minicourses. The eight minicourses were: "Things That Last," "The Computer Age," "Buying and Selling," "Packaging Passengers," "Heart Attack," "Getting Enough Oxygen," "The Generation Link," and "Gut Reactions."

A diagnostic instrument containing 32 factual style questions was administered to 112 Oklahoma secondary science teachers. The questions on the instrument were drawn from ISIS test booklets covering each of the eight minicourses.

The percentage of correct responses on the instrument were computed for each respondent. The population mean was 65 percent of the 32 questions answered correctly.

The questions for each minicourse were grouped together. The percent of the total possible correct answers was calculated for each minicourse. The percent of the possible correct answers answered correctly ranged from 47 percent to 87 percent.

Personal data was tabulated and shown with average total percentages in each category. A two by three contingency table was used to study the possible relationship between performance on instrument and type of degree held and undergraduate major of respondent. Both relationships failed to reach significance at the .05 confidence level.

Discussion of Results

The results indicate a need for instruction in those scientific principles contained in the eight ISIS minicourses investigated. The average percentage of the questions correctly answered was 65 percent for the responding population tested. According to most grading systems, this score would be below average.

The most revealing set of data is that found in Table II. The subjects' averages were less than 70 percent of the possible correct answers on six of the eight minicourses. The average score on the eight minicourses was 65 percent, the population mean. The minicourse averages indicate that teachers need to strengthen their knowledge of subject matter materials contained in at least six of the eight minicourses.

The sample population evidently was quite familiar with the principles contained in the minicourse "Buying and Selling" because 88 percent of the answers were correct. The high percentage on this minicourse is not surprising because society is constantly being encouraged to respond to advertisements.

On the minicourse "The Computer Age" the respondents scored less than 50 percent. Although the computer touches all of society, understanding of the computer is relegated to a few who build, repair, program, and operate them. Most of society has never been exposed to the principles of computer technology. So it is not surprising that the low percentage was obtained.

The respondents averaged 69 percent correct answers on the minicourse "The Generation Link." This minicourse contains scientific principles associated with heredity. This low average was surprising because the scientific principles presented in the minicourse, are found in virtually all life science textbooks written on the secondary and college levels.

The personal data revealed several important facts. For the population studied, the types of degree held by respondents had no significant relationship to their performance on the instrument. That is, those with a bachelor's degree apparently performed as well as those with a master's (or above) degree. This could have several implications which will be discussed later. Statistical analysis of the possible relationship between undergraduate major and performance revealed no significant relationship between major and performance on diagnostic tool. Whether the respondents majored in the physical sciences or the biological sciences apparently had little to do with their performance on the instrument. One possible explanation for this finding is that life science majors are required to study some of the physical sciences; this is in keeping with Paul Hurd (22), the AAAS Guidelines (15), and the AETS Guidelines (16). Both sets of guidelines suggest a broad science program for science majors plus concentration in a specialty field. In keeping with the literature, the majors in the physical sciences take college hours in the life sciences. Most of the respondents had greater than 11 hours of physical and biological sciences. Therefore, the rather broad educational experiences in the various sciences could have accounted for this finding of no significant relationship.

Most of the instrument averages for each category on all of the personal data questions were close to the population mean of 65 percent. Since the two personal data questions submitted to statistical analysis show no significant relationship, it is quite probable that factors listed in personal data have little relationship to performance on the diagnostic instrument.

Implications of the Study

The results of this study seem to indicate a need for specific education related to the scientific principles contained in the eight ISIS minicourses investigated. Hurd (22), among other authorities, has made this observation in several of his publications. This means that preservice and inservice education needs to be aimed directly at those principles with which the respondents are unfamiliar, especially if the respondents are to effectively implement the ISIS program. The 65 percent population mean indicates a rather strong inadequacy as far as the factual knowledge of scientific principles contained in the eight ISIS minicourses is concerned. Hurd (21) and Jacobsen (26) are in agreement with the writer who suggests that before teachers implement a program, in this case, ISIS, that they attend an inservice course specifically designed to deal with scientific principles contained in the minicourses which they expect to teach. This inservice course should be designed to allow the teacher to study those areas where he needs to strengthen his factual knowledge.

The statistical acceptance of no difference in type of degree held and performance on instrument implies that an increase in number of college hours beyond a point seems to be of little value to sample teachers' factual knowledge of scientific principles contained in the eight minicourses investigated. If this is true, then the writer suggests that a part of college work beyond the bachelor's degree be centered around the study of relative scientific and technological principles and refinement of pedagogical techniques. The teacher education institutions should develop comprehensive science education programs which will increase factual knowledge of relevant scientific principles of the areas the teacher plans to teach, and should provide ample opportunity to study ways to effectively integrate these principles.

Future research should involve (1) designing and evaluating inservice and preservice college courses dealing with specific and relevant principles of science and technology and society; (2) testing of ISIS and other multidisciplinary programs; and (3) when ISIS modules are completed, test inservice teachers over their factual knowledge of scientific principles contained in these ISIS minicourses.

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APPENDIX A

LETTER OF INTRODUCTION

John E. Hurn
LSW 211
O.S.U.
Stillwater, Oklahoma,
74074

December 11, 1974

Dear Science Teacher:

Under the supervision of Dr. Tom Johnsten, Professor of Science Education, Oklahoma State University, I am developing a diagnostic instrument which will be used to assess the relevance of the secondary science education program at Oklahoma State University.

Will you please help me in this endeavor by allowing me to personally administer the proposed diagnostic instrument? It will require approximately 30-45 minutes of your time. In compiling the data, no reference will be made to respondents or schools.

If you wish to help, please drop enclosed card in the mail. I will contact you later to arrange a time to administer the diagnostic instrument.

Sincerely,

John E. Hurn
JEH/gm

APPENDIX B

LETTER TO PRINCIPALS

John E. Hurn
LSW 211
O.S.U.
Stillwater, Oklahoma,
74074

Dear Principal:

______________________________, a science teacher on your staff, has graciously consented to help me on a study I'm doing at Oklahoma State University. I have contacted this person by phone, and he/she has indicated a further willingness to help by taking a diagnostic examination.

In order to satisfy my committee members, I must either administer the tool myself or go through an administrator. Therefore, I'm asking that you take a minute or two of your time and contact the above teacher, informing him/her that the tool is in your office. The teacher may then come to the office area and take the diagnostic tool at his/her earliest convenience. The teacher will then simply place completed tool in stamped envelope and place it in the mail.

It is imperative that the teacher utilize no helps while working on the tool, and that 30 minutes be a maximum time limit.

Your help in this study will make it possible for the study to be completed. It is hoped that the conclusion of this study will result in science education courses at Oklahoma State having greater relevance to teachers' needs.

Sincerely,

John E. Hurn
Graduate Assistant, Oklahoma State University
Instructor, Langston University

APPENDIX C

LETTER TO TULSA TEACHERS

John E. Hurn
LSW 211
O.S.U.
Stillwater, Oklahoma
74074

February 22, 1975

Dear

I would like to express my appreciation to you for offering to help me in a study I'm doing at Oklahoma State. It is good to know that my friends in Tulsa are still there when I need them.

I am asking that you meet with me on Thursday afternoon at 4:00 P.M., at the headquarters of the TCTA on east 31st street across from Education Service Center. While there, we can have coffee and donuts and I can administer the 30-minute diagnostic tool to you.

Incidently, I'll have some activity packets covering material from Technology-People-Environment and The Man Made World. As a way of saying thanks, I'll give you a packet as you leave.

I hope to see you Thursday afternoon at 4:00 P.M.

Sincerely,

John E. Hurn
Graduate Assistant, Oklahoma State University
Instructor, Langston University

APPENDIX D

ANSWERS TO INSTRUMENT ITEMS

ANSWERS TO INSTRUMENT ITEMS

1.	(c)	17.	(e)
2.	(a)	18.	(e)
3.	(c)	19.	(e)
4.	(b)	20.	(c)
5.	(d)	21.	(a)
6.	(c)	22.	(b)
7.	(a)	23.	(b)
8.	(a)	24.	(b)
9.	(a)	25.	(c)
10.	(c)	26.	(c)
11.	(b)	27.	(e)
12.	(d)	28.	(b)
13.	(a)	29.	(e)
14.	(e)	30.	(c)
15.	(c)	31.	(a)
16.	(a)	32.	(a)

APPENDIX E

DIAGNOSTIC INSTRUMENT

NOTE

1. Please complete all questions.
2. Place completed instrument in envelope and seal same.
3. I will take great care in assuring COMPLETE anonymity.
4. Please fill out attached card and give it to me. This card will be used only as a record so that I can send you a summary copy of the completed project.
5. I owe you many thanks for participating in this study.

THANK YOU!

PERSONAL INFORMATION

DIRECTIONS: Please circle the appropriate letter.

1. Number of years of teaching experience?
   a. 0-2 c. 6-10 e. 16-20
   b. 3-5 d. 11-15 f. 21+

2. Number of years of teaching in the present school system?
   a. 0-2 c. 6-10 e. 16-20
   b. 3-5 d. 11-15 f. 21+

3. What was your undergraduate major in college?
   a. Physical Sciences (Chemistry or Physics) c. Math
   b. Life Sciences (Biology) d. Other ____________

4. Number of hours of college credit in the Physical Sciences?
   a. 0-10 c. 21-30 e. 41-50
   b. 11-20 d. 31-40 f. 51+

5. Number of hours of college credit in the Life Sciences?
   a. 0-10 c. 21-30 e. 41-50
   b. 11-20 d. 31-40 f. 51+

6. What is the highest degree that you hold?
   a. B.A. c. M.S. e. Ed.S. g. Other __________
   b. B.S. d. M.S. plus hours f. Ed.D.

7. Number of years that have elapsed since attending a college level class as a student?
   a. 0-2 c. 6-10 e. 16-20
   b. 3-5 d. 11-15 f. 21+

8. What is your age?
   a. 20-30 c. 41-50 e. Over 60
   b. 31-40 d. 51-60

9. In what type of school do you teach?
   a. Public b. Private c. Parochial

10. What is the approximate population of the city in which you teach?
    a. Under 10,000 c. 20,000-75,000
    b. 10,000-20,000 d. Over 75,000

11. What is the enrollment of the school in which you teach?
    a. Less than 200 c. 401-800 e. Over 1,200
    b. 201-400 d. 801-1,200

12. How many secondary science teachers are in your school?
    a. 1 b. 2 c. 3 d. 4 e. 5 f. 6 g. Over 6

13. Did you attend any of the science meetings at the State Teachers' Convention in Tulsa in October of last year?
    a. Yes   b. No

14. Are you a member of any Oklahoma or National science teachers' organizations?
    a. Oklahoma   b. National   c. Both   d. Neither

DIRECTIONS:
1. Please read each question carefully.
2. Circle the correct answer to each question.

1. Most digestion occurs in the
   A. ilium
   B. stomach
   C. small intestine
   D. large intestine

2. Circle the example which shows the relationship between alleles and genes.
   A. Brown hair and black hair are caused by alleles of the same genes.
   B. Brown hair and black hair are caused by genes of the same allele.
   C. Brown hair and blue eyes are caused by alleles of the same gene.
   D. Brown hair and blue eyes are caused by genes of the same allele.
   E. Alleles and genes are unrelated to each other.

3. Which would more likely cause the most serious injury at the same speed, hitting the end of a pole or hitting a brick wall? Choose the answer and reason below.
   A. Hitting the wall because a greater area of the body's surface hits it
   B. Hitting the wall because its larger mass produces an equal reaction
   C. Hitting the end of the pole because its smaller surface area hits the body
   D. Hitting the end of the pole because its surface would be smoother
   E. Either because the force depends only on the weight and speed, which are the same in both cases

4. What is the difference between systolic pressure and diastolic pressure?
   A. Systolic pressure occurs when the heart is resting. Diastolic pressure occurs when the heart is pumping.
   B. Systolic pressure occurs when the heart is pumping. Diastolic pressure occurs when the heart is resting.

C. Systolic pressure occurs when a person develops hardening of the arteries.
Diastolic pressure occurs when a person develops softening of the arteries.
D. Systolic pressure occurs when a person develops softening of the arteries.
Diastolic pressure occurs when a person develops hardening of the arteries.

5. How does gas exchange take place in the lungs?
A. Oxygen enters the bloodstream in the bronchial tubes, and carbon dioxide leaves the blood in the alveoli.
B. Oxygen enters the bloodstream in the alveoli, and carbon dioxide leaves the blood in the bronchial tubes.
C. Carbon dioxide and oxygen are exchanged in the bronchial tubes.
D. Carbon dioxide and oxygen are exchanged in the alveoli.
E. At different times, a different process takes place, depending on whether the person is resting, doing moderate work, or doing heavy exercise.

6. The following are properties of alloys that make the alloys different from the metals that form them:
1. greater hardness,
2. lower melting point, and
3. more resistant to corrosion

Which of the following correctly matches the alloys with the three properties listed above?

A.	B.	C.	D.
1. Bronze	1. Steel	1. Steel	1. Bronze
2. Steel	2. Bronze	2. Solder	2. Solder
3. Solder	3. Solder	3. Bronze	3. Steel

7. When a metal is coated with zinc, the process is called
A. galvanizing.
B. alloying.
C. electroplating.
D. metallizing.
E. zinc plating.

8. What is the order for carrying out a market analysis?
A. (1) State the hypothesis. (2) Design a procedure. (3) Collect the data. (4) Tabulate the results. (5) Draw conclusions.
B. (1) Design the procedure. (2) State the hypothesis. (3) Collect the data. (4) Tabulate the results. (5) Draw conclusions.
C. (1) Design the procedure. (2) Tabulate the results. (3) Collect the data. (4) State the hypothesis. (5) Draw conclusions.
D. (1) State the hypothesis. (2) Draw conclusions. (3) Design the procedure. (4) Collect the data. (5) Tabulate the results.

9. When a gene mutates, how does DNA change chemically?
A. The arrangement of nucleotides in DNA changes.
B. The number of DNA molecules in the cell changes.
C. The DNA molecule fails to duplicate itself.

D. The DNA molecules are destroyed.
E. All of the above could happen.

10. The "Lock and Key" theory of enzyme activity
A. refers to specific complimentarity between an enzyme and its specific rRNA.
B. assures that rRNA will be able to travel to location of mRNA during protein synthesis.
C. describes the relationship of enzyme and substrate reactions.
D. has been shown to disprove enzyme specificity.

11. What is an algorithm?
1. A number that tells the power to which another number is raised
2. A step-by-step procedure to follow to get something done
3. A kind of literature
4. A kind of music
5. None of the above

12. Here is a BASIC program for a computer.

```
10 READ A1, A2, A3, A4, A5, A6
20 PRINT A1, A3, A5
30 DATA 10, 11, 12, 13, 14, 15
END
```

Which numbers will be provided as output?
A. 10, 11, 12
B. A1, A2, A3, A4, A5
C. A1, 10, A3, 12
D. 10, 12, 14
E. 11, 13, 15

13. If a couple has three boys, what are the chances that their next child will be a girl?
A. 1 out of 2
B. 1 out of 4
C. 1 out of 8
D. 1 out of 16
E. 1 out of 46

14. One of the main parts of a computer is the control section. Which of the following describes what the control section does?
A. It punches holes in the computer punch card.
B. It stores data in its cells.
C. It does the arithmetic on the problem.
D. It supplies the answer to the problem in printed form.
E. It handles the flow of data through the computer.

15. Air embolism is
A. the same as the bends.
B. caused by a failure to hold the breath while rising.
C. caused by air entering the blood from over-inflated lungs.
D. due to the narcotic effect of nitrogen at depths of about 200 feet.
E. a result of hyperventilation before diving.

16. What methods do ads use to teach you their message?
    A. Repetition, keeping the message simple, and relating the product to pleasant things
    B. Repetition, information, and a detailed statement of fact
    C. Information, stating the advertising techniques being used, and discussing data
    D. Repetition, memorization, and comparison
    E. Repetition, stating advantages and disadvantages, and urging you to pay cash

17. Which statement describes a second collision in a head-on crash?
    A. A third car crashes into two wrecked cars.
    B. One of the wrecked cars bounces into a nearby parked car.
    C. A passenger is thrown into the back seat.
    D. A passenger is thrown out of the car through an open window.
    E. A passenger smashes into the windshield.

18. Twins have been studied to find out if a characteristic is inherited or caused by the environment. Which of the following suggests that the environment produced the characteristic rather than genes?
    A. Identical twins reared together both show the characteristic.
    B. Identical twins reared apart both show the characteristic.
    C. Fraternal twins reared together both show the characteristic.
    D. Fraternal twins reared together do not both show the characteristic.
    E. None of the above would suggest that conclusion.

19. Which decimal number is equal to the binary number 111010?
    A. 4 B. 8 C. 10 D. 34 E. 58

20. Digestive enzymes are very sensitive to pH. Pepsin, a proteolytic enzyme, is most effective at which pH?
    A. 7-8 B. 4-5 C. 1-3 D. 5.5-6.5

21. "A body in motion continues in motion in the same direction and at the same speed unless an unbalanced force acts on it." Which statement below is not explained by that law?
    A. A car slows down quicker if it runs into a brick wall rather than into a wooden fence.
    B. A cyclist can be thrown over the handlebars if his front wheel locks.
    C. It is dangerous to stand unsupported in a moving bus.
    D. A passenger falls forward when a driver slams on the brakes.
    E. The load may slide off the side of a truck if the driver turns too sharply.

22. The walls of the small intestine are thrown into many folds. The folded nature of the intestinal wall:
    A. provides "stretchability" so one may eat more food.
    B. increases the absorptive surfaces.
    C. provides for increased secretion of pancreatic juices containing proteolytic, lipolytic, and amyltic enzymes.

D. increases the amount of intestine which can be removed without damage to digestive process.

23. Slogans have been called secret teachers. Their chief purposes are to
A. stress cost and quality.
B. teach a brand name and help you remember it.
C. entertain and amuse you.
D. encourage you to shop and compare.
E. test and rate the product.

24. An example of a visual illusion used in advertising is
A. a package that appears larger than it is.
B. using special shapes.
C. all of the above.
D. none of the above.

25. What is a mole?
A. 6 X 10^{23} atoms or molecules
B. Equal to the atomic weight of an element or compound in grams
C. Both A and B
D. Neither A or B

26. Four people were involved in a serious accident. The table below shows the blood group of each of the victims.

PERSON	BLOOD GROUP
1	A
2	B
3	AB
4	0

Which victim or victims could safely receive a transfusion of blood from an AB donor?
A. Persons 1, 2, 3
B. Persons 3 and 4
C. Person 3 only
D. All would be safe because AB is the universal blood donor.

27. Aluminum is more active than iron. Therefore,
A. a solution of an aluminum compound can be used to plate an iron tack by a single replacement action.
B. aluminum will not be corroded by acid.
C. iron will not be corroded by acid.
D. neither iron nor aluminum will be corroded by acid.
E. a solution of an iron compound can be used to plate an aluminum tack by a single replacement reaction.

28. A 3-kg toy car traveling at 5 kph collides head-on with a 6-kg toy truck traveling at 7 kph in the opposite direction. What is the velocity after the collision? (Assume that the car has the + direction and that the car and truck lock bumpers in the collision.)
A. 0 kph B. -3 kph C. +3 kph D. -27 kph E. 57 kph

29. The respiration of glucose in the cell may be summarized like this.

$C_6H_{12}O_6$ (1 glucose) + $6O_2$ (oxygen)

What are the results of this reaction?

A. $2(C_3H_6O_3)$ (Pyruvic acid) + $3H_2O$ + $2CO_2$ + 18 ATP

B. $2(C_3H_6O_3)$ (Pyruvic acid) + 2 ATP

C. $3CO_2$ + $6H_2O$ + 36 ATP

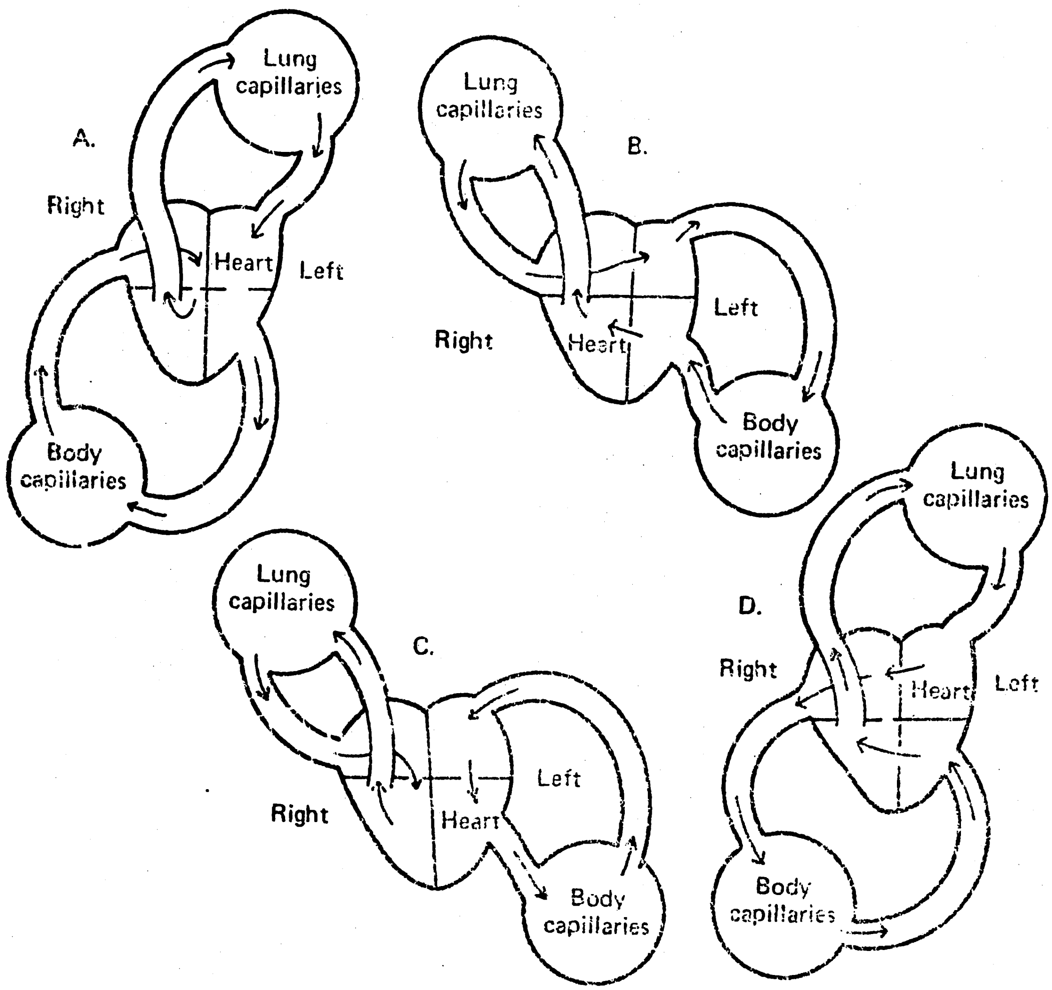
D. $6CO_2$ + $6H_2O$ + 18 ATP

E. $6CO_2$ + $6H_2O$ + 38 ATP

30. Which person is most likely to have a heart attack?
A. A cigarette smoker with low blood pressure and a low cholesterol diet
B. A nonsmoker with high blood pressure and a high cholesterol diet
C. A cigarette smoker with high blood pressure and a high cholesterol diet
D. A nonsmoker with low blood pressure and a low cholesterol diet

31. What happens to the solubility of a gas in water when the pressure increases?
A. More gas will dissolve in the water.
B. Less gas will dissolve in the water.
C. The solubility of gases remains the same.
D. Certain gases become more soluble, and other gases become less soluble.
E. Nothing happens because gases are not soluble in water.

32. Which one of these diagrams shows the way the blood flows through the heart?



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VITA

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Candidate for the Degree of

Doctor of Education

Thesis: SURVEY OF OKLAHOMA SECONDARY SCIENCE TEACHERS AND THEIR FACTUAL KNOWLEDGE OF SCIENTIFIC PRINCIPLES CONTAINED IN EIGHT ISIS MINICOURSES

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